Stoller
Hanford Office

DOE-EM/GJ922-2005

299-W15-08 (A5468)
Log Data Report

Borehole Information:

Borehole:	299-W-15-08 (A5468)		Site:	216-Z-9 Crib	
Coordinates (WA State Plane)		GWL (ft)[1]: Dry		GWL Date: 05/04/05	
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
135576.698	566757.68	11/66	671.63	206	Cable

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Carbon steel	N/A[3]	8	unknown	unknown	N/A	106.5
Carbon steel	2.25	6	unknown	unknown	2.25	206.0
Carbon steel	N/A	4	unknown	unknown	N/A	178.0

Borehole Notes:

Casing information is derived from *Hanford Wells* (Chamness and Merz 1993). Grout is reported between the 4-, 6-, and 8-in. casings to 178 ft. The 4-in. casing was placed to a packer set at 178 ft. Below 178 ft, the 6-in. casing extends to the bottom of the borehole at 206 ft. The 6-in. casing is perforated from 180 to 195 ft.

The logging engineer measured the casing stickup for the 6-in. casing, which is the logging depth reference point. Both the 4- and 8-in. casings are visible at the ground surface but are below the 6-in. casing.

Logging Equipment Information:

Logging System:	Gamma 2B		Type: SGLS (35%) 36TP21095A
Calibration Date:	03/04	Calibration Reference:	DOE-EM/GJ647-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 2A		Type: SGLS (35%) 34TP20893A
Calibration Date:	03/04	Calibration Reference:	DOE/EM/GJ642-2004
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Logging System:	Gamma 2L		Type: Passive Neutron U1754
Calibration Date:	None	Calibration Reference:	None
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	3	4 - Repeat	5 Repeat	6	7
Date	04/07/05	04/12/05	04/12/05	04/12/05	04/14/05
Logging Engineer	Pope	Pope	Pope	Pope	Pope
Start Depth (ft)	40.0	53.0	80.0	77.0	0.0
Finish Depth (ft)	78.0	53.0	80.0	146.0	41.0
Count Time (sec)	200	1000	1000	200	200
Live/Real	R	R	R	R	R
Shield (Y/N)	N	N	N	N	N
MSA Interval (ft)	1.0	N/A	N/A	1.0	1.0
ft/min	N/A	N/A	N/A	N/A	N/A
Pre-Verification	BB176CAB	BB177CAB	BB177CAB	BB177CAB	BA378CAB
Start File	BB176000	BB177000	BB177001	BB177002	BA378000
Finish File	BB176038	BB177000	BB177001	BB177071	BA378038
Post-Verification	BB176CAA	BB177CAA	BB177CAA	BB177CAA	BA378CAA
Depth Return Error (in.)	+ 0.7	N/A	N/A	0	N/A
Comments	Fine-gain adjustment made at file -022.	No fine-gain adjustment.	No fine-gain adjustment.	Fine-gain adjustment made at files -031 and -061.	Fine-gain adjustment made at files -009 and -031.

Log Run	8				
Date	04/14/05				
Logging Engineer	Pope				
Start Depth (ft)	145.0				
Finish Depth (ft)	202.5				
Count Time (sec)	200				
Live/Real	R				
Shield (Y/N)	N				
MSA Interval (ft)	1.0				
ft/min	N/A				
Pre-Verification	BA378CAB				
Start File	BA378039				
Finish File	BA378097				
Post-Verification	BA378CAA				
Depth Return Error (in.)	- 0.5				
Comments	Fine-gain adjustment made at files -039, -056 and -068.				

Passive Neutron Logging System (PNLS) Log Run Information:

Log Run	1	2 Repeat			
Date	04/05/05	04/05/05			
Logging Engineer	Pope	Spatz			
Start Depth (ft)	150.0	70.0			
Finish Depth (ft)	50.0	49.0			
Count Time (sec)	N/A	100			
Live/Real	R	L			
Shield (Y/N)	N	N			
Sample Interval (ft)	0.25	0.25			

Log Run	1	2 Repeat			
ft/min	1.0	N/A			
Pre-Verification	BI000CAB	BI000CAB			
Start File	BI000000	BI000401			
Finish File	BI000400	BI000485			
Post-Verification	BI000CAA	BI000CAA			
Depth Return Error (in.)	N/A	+ 1			
Comments	None	None			

Logging Operation Notes:

Passive neutron logging was performed in the borehole from 49 to 150 ft on April 5, 2005.

Logging was also conducted April 7 and 12, 2005, using SGLS logging system Gamma 2B and on April 14, 2005, using Gamma 2A. Pre- and post-survey verification measurements for the SGLSs employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 082. Two depth intervals were selected for longer count times (1000 seconds) at 53 and 80 ft to improve the counting statistics and reduce the MDL for man-made radionuclides, and to consider the relationships between the passive neutron count rate and individual alpha-emitting radionuclides. The depth interval at 53 ft was selected at the highest passive neutron count rate and the interval at 80 ft where minimal passive neutron count rates were observed.

All measurements were performed with no centralizer installed on the sondes. The top of the 6-in. casing is the reference point for depth.

Analysis Notes:

Analyst:	Henwood	Date:	05/23/05	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS verification spectra were collected at the beginning and end of each day. Two different logging systems were used over three days to complete the log. Both systems were last calibrated in March 2004, with relatively little use since that time. Time constraints did not allow time for recalibration prior to logging this borehole, and the presence of 4-in. inner-diameter (ID) casing prevented the use of the 70% HPGe detector.

Results of pre- and post-run verification spectra were compared to criteria developed from the March 2004 calibration. Gamma 2B exhibited an increase in net counts for the 2615 keV peak, exceeding the HASQARD 20% criterion. The 609 and 1461 keV peaks were consistent with the verification criteria, although there was one instance where the net counts for the 609 keV peak were slightly above the upper control limit. This suggests an improved efficiency relative to the March 2004 calibration data, and the cause for this is unknown. The increase in net counts for the 2516 peak will have minimal effect on man-made radionuclides, since quantification is based on net counts for peaks less than 1461 keV. However, it is possible that values for ^{232}Th may be slightly overestimated. On April 12, (log runs 4, 5 and 6) the Gamma 2B system exhibited a decrease of approximately 11 percent in net counts from the pre-run verification to the post-run verification. Examination of the spectra show no evidence of system malfunction, and verification spectra for Gamma 2B are provisionally accepted.

Net counts from Gamma 2A verification spectra are within control limits, but the Gamma 2A system appears to have suffered a slight decrease in energy resolution relative to the March 2004 calibration. Since the net counts are within acceptance criteria, the degradation of resolution does not appear to affect results, and the spectra are provisionally accepted.

After this borehole was completed, the Gamma 2B detector failed before calibration measurements could be made. The Gamma 2A system appears to be functional, but cable problems with the Gamma 2 logging system have delayed calibration activities. Therefore, the data from 299-W15-08 were processed and analyzed using the March 2004 calibration data for both logging systems. It is likely that both systems exhibit a somewhat higher degree of error in concentration values than usual, but detection and identification of specific radionuclides is unaffected.

An AmBe neutron source was used for verification measurements with the PNLS. Currently, there are no verification criteria established for this system. The counts obtained from the pre and post verifications were within 1 percent.

Log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source files: G2AMarJan04.xls and G2BMar04.xls for the respective logging systems). A combined casing correction for a 0.839-in.-thick casing (0.322+0.280+0.237) was applied for the 8-, 6-, and 4-in. casings to 106 ft. From 106 to 178 ft (6- and 4-in. casings), a combined correction of 0.517 in. was applied; a correction for 0.237 in. was applied below 178 ft. Dead time corrections were applied to Gamma 2A and 2B where the dead times exceeded 10.5 and 7.5 percent, respectively. No water corrections were required.

Log Plot Notes:

Separate log plots are provided for gross gamma and passive neutron, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Man-made plots are included for ^{241}Am, ^{233}Pa, and ^{239}Pu that compare assays using different gamma energy peaks. A combination plot that includes man-made and natural radionuclides, total gamma, and passive neutron is provided. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited slightly higher net counts per second.

A comparison plot of man-made radionuclides assayed in 1992 using the Westinghouse Hanford Company Radionuclide Logging System (RLS) and the current SGLS data is provided. In addition, a plot of historical total gamma data acquired in 1968, 1970, and 1972 is included.

Results and Interpretations:

^{233}Pa, ^{241}Am, and ^{239}Pu were the man-made radionuclides detected in this borehole. ^{233}Pa, which reflects the concentration of its parent ^{237}Np, was detected between 52 and 124 ft with a maximum concentration of approximately 23 pCi/g at 118 ft. The energy peak at 312 keV is used to assay ^{233}Pa. The ^{233}Pa energy peak comparison plot indicates that concentrations determined from gamma energy peaks at 375.45 and 415.76 keV that originate from ^{233}Pa decay are likely, in part or in whole, influenced by other radionuclides that emit gamma rays near these energies. The other man-made radionuclides detected in this borehole include ^{239}Pu and ^{241}Am. Decay of ^{239}Pu results in gamma ray emissions at the 375.05 and 413.71 keV energy peaks and ^{241}Am decay results in gamma emissions at 376.66 and 415.88 keV. Contributions to these specific energy peaks cannot be segregated in the SGLS spectra; an energy peak typically encompasses gamma rays over a 3 keV range.

^{241}Am (662.4 keV) was detected almost continuously from 52 to 127 ft at concentrations ranging from just above the MDL of approximately 20,000 pCi/g to 235,000 pCi/g; the maximum concentration was measured at 53 ft. Energy peaks possibly attributable to ^{241}Am were detected at approximately 208.01, 662.40, 722.01, 376.65, and 415.88 keV (see ^{241}Am Plot). The assays derived from the 376.65 and 415.88 keV energy peaks are clearly overestimated. This overestimation is the result of contributions from 375.05 and 413.71 keV (^{239}Pu) and 375.45 and 415.76 keV (^{233}Pa) energy peaks. The assays of the ^{241}Am based on gamma rays at 662.40 and 722.01 keV roughly coincide. Because the gamma rays from the 622.40 keV energy peak have a slightly higher yield than the 722.01 keV energy peak, the former is used to provide the assay for ^{241}Am. In addition, the 722.01 energy peak has minor interfering gamma rays from ^{208}Tl at 722.04 keV that may cause a slight overestimation of concentrations.

The ^{241}Am concentrations derived from the 208.01 keV gamma line also appear to be slightly overestimated. A 208.000 keV gamma line that results from the decay of ^{237}U, interferes with the 208.01 keV gamma line caused by the decay of ^{241}Am. These nearly coincident peak energies cannot be resolved with the SGLS. The presence of ^{237}U indicates that ^{241}Pu is still present. ^{240}Pu may also exist in the waste stream; however, there are few gamma rays associated with the decay of ^{240}Pu.

Interference of the 662.40 energy peak could be caused by the ^{137}Cs gamma ray at 661.62 keV. However, because the assays for ^{241}Am originating from the 722.01 and 662.40 keV energy peaks generally coincide, it is likely the gamma rays at this energy can be attributed to ^{241}Am, and that little or no ^{137}Cs is present.

^{239}Pu was detected between 52 and 70 ft and may exist at levels below its MDL (approximately 35,000 pCi/g) to a similar depth as the ^{241}Am and ^{233}Pa. The maximum concentration was measured at approximately 350,000 pCi/g at 53 ft. It was also detected at sporadic depth locations between 70 and 110 ft. Energy peaks associated with ^{239}Pu were detected at approximately 375, 380, and 414 keV (see ^{239}Pu plot). The 375.05-keV energy peak has the highest yield of these energy peaks at 0.0016 percent and was utilized to determine concentrations. Interferences from the 375.45 and 376.65 keV energy lines and the 415.76 and 415.88 keV gamma energy lines originating from the decay of ^{233}Pa and ^{241}Am, respectively, are probable and would result in a slight overestimation of the ^{239}Pu concentration.

Passive neutron logging was performed in the borehole from 49 to 150 ft. This logging method has been shown to be effective in qualitatively detecting zones of alpha-emitting contaminants from secondary neutron flux generated by the (α,n) reaction and may indicate the presence of alpha-emitting nuclides, including transuranic radionuclides, even where no gamma emissions are available for detection above the MDL. The passive neutron signal depends on the concentration of alpha sources and also the concentrations of lighter elements such as N, O, F, Mg, Al, and Si, which emit neutrons after alpha capture. This logging system cannot be calibrated, and the data are qualitative only. The passive neutron detector indicates elevated count rates between 50 and 125 ft. The highest count rates are detected at approximately 53, 65, and 108 ft. ^{239}Pu was the dominant radionuclide detected at these depths. ^{241}Am and ^{233}Pa were also detected at each of these depths, except at approximately 65 ft where no ^{241}Am was detected. It is possible these radionuclides and perhaps other isotopes of Pu exist continuously throughout the relatively high neutron count rate interval (50 to 125 ft), even where no isotope was explicitly identified from gamma activity at levels above the respective MDLs.

An energy peak at approximately 2223 keV was identified at 53 ft in a spectrum acquired at a 1000-sec counting time. The peak is almost certainly due to the 2223.2-keV H capture gamma-ray. The existence of this peak indicates the presence of neutron activity in the subsurface so that neutron capture events with H produce a detectable 2223.2-keV capture gamma-ray. The neutrons presumably come from (α,n) reactions with a lighter element, which indicates high concentrations of alpha-emitting nuclides. This depth interval coincides with the highest concentrations of transuranics in the borehole determined with the SGLS and PNLS.

The ^{40}K, ^{238}U, and ^{232}Th logs show probable influences from grout placed in the borehole between the 4-, 6- and 8-in. casings such that the usually prominent Cold Creek Interval cannot be discerned. It is likely the top of this unit is at approximately 125 ft where the man-made radionuclide contamination apparently ends.

The Westinghouse Hanford Company acquired spectral gamma data in this borehole in 1992, using the RLS. A comparison plot of these data and the current log data is included that shows some differences in data acquisition and analysis procedures. Important differences in logging protocol in 1992 and 2005 include:

In 1992, logging was conducted in a dynamic mode at 0.6 ft/minute such that counts were acquired and written to a data file at 0.5 ft intervals. The counting time for the 0.5 ft interval was approximately 50 seconds. The current protocol results in a stationary measurement acquired at discrete 1-ft intervals for 200 seconds. While the spatial resolution is enhanced in the 1992 data, the counting statistics of the current data are greatly increased, resulting in reduced error of the measurement.

The 1992 data were acquired with an 18-percent efficient detector while the SGLS is approximately 35 percent efficient, almost twice the detection capability of the 1992 system.

The analyses used in 1992 only used one correction for casing thickness in excess of 0.4-in. Apparently there are three casings in borehole 299-W-15-08 with an additive thickness of approximately 0.839-in. to 106 ft. Thus, calculated concentrations are low in the 1992 data. The current analysis protocol provides for casing corrections for each thickness.

Even with these possible deficiencies, the 1992 logging provided assays of ^{239}Pu and ^{233}Pa in borehole 299-W15-08 that are comparable to the data acquired in 2005. However, the analysis in 1992 of the 299-W-15-08 borehole data concluded the counts detected in the 662 keV energy peak were the result of ^{137}Cs (661.66 keV). It is concluded in the current analysis that the 662 keV energy peak is the result of the 662.40 keV gamma ray associated with ^{241}Am. This conclusion is based on the detection of a confirming ^{241}Am peak at 722 keV. Thus, a relatively low concentration of ^{137}Cs reported in the 1992 data actually represents a significantly higher concentration of ^{241}Am.

The comparison plot indicates the 1992 data analysis underestimated the concentrations for ^{233}Pa and ^{239}Pu from 50 to 106 ft because of the 0.4-in. casing limitation in 1992. If the current SGLS data are re-analyzed using a 0.4-in. thick casing, calculated concentrations are very similar to the 1992 data.

Historical total gamma data acquired in 1968, 1970, and 1972 have been re-digitized from Fecht et. al. (1977). These data indicate a profile consistent with the current SGLS total gamma profile, suggesting no significant changes since 1968.

Repeat data points were acquired at a 1000-second counting time at 53 and 80 ft. These data are included in the main logs. No other repeat data were acquired with the SGLS. A passive neutron repeat section also shows good repeatability.

The detection of ^{137}Cs in the 1992 RLS logs in borehole 299-W15-08 raises important concerns about interpretation of previous log data at the Hanford Site, particularly where transuranic radionuclides such as plutonium, americium, or neptunium are concerned. Experience has shown that the prominent 59.54 keV gamma line typically associated with ^{241}Am is unlikely to be detected in cased holes. Mis-identification of the 662.4 keV gamma line from ^{241}Am as ^{137}Cs has serious ramifications with regard to contaminant concentrations because of the difference in gamma yields. What appears to be 1 pCi/g of ^{137}Cs may in fact be 234,000 pCi/g of ^{241}Am. Older log data from boreholes in the vicinity of Z Plant should be re-evaluated with this in mind, and new logs should be run whenever possible to provide better quality data. It should be noted that while ^{137}Cs is a common contaminant over much of the Hanford Site, it is less likely to be present in waste streams associated with the later steps of plutonium processing. In addition, the passive neutron log should be run in these boreholes since the presence of neutron activity is a qualitative indicator of alpha emissions from transuranic radionuclides.

References:

Chamness, M.A., and J.K. Merz, 1993. *Hanford Wells*, PNL-8800, Pacific Northwest Laboratory, Richland, Washington.

Fecht, K.R., G.V. Last, and K.R. Price, 1977. *Evaluation of Scintillation Probe Profiles from 200 Area Crib Monitoring Well*s, ARH-ST-156, Atlantic Richfield Hanford Company, Richland, Washington.

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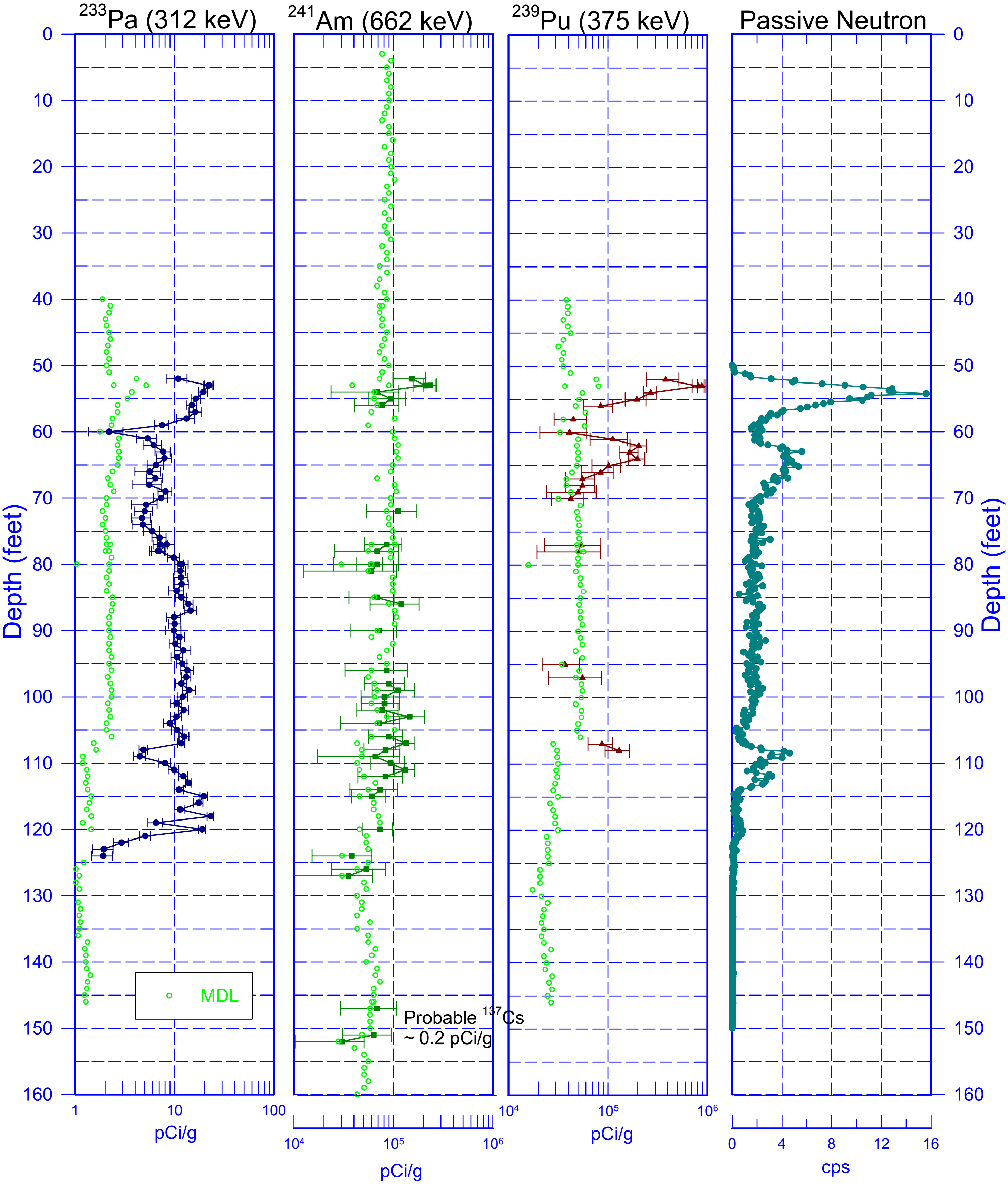
[1] GWL – groundwater level
[2] TOC – top of casing
[3] N/A – not applicable

299-W15-08 (A5468)
Man-Made Radionuclides

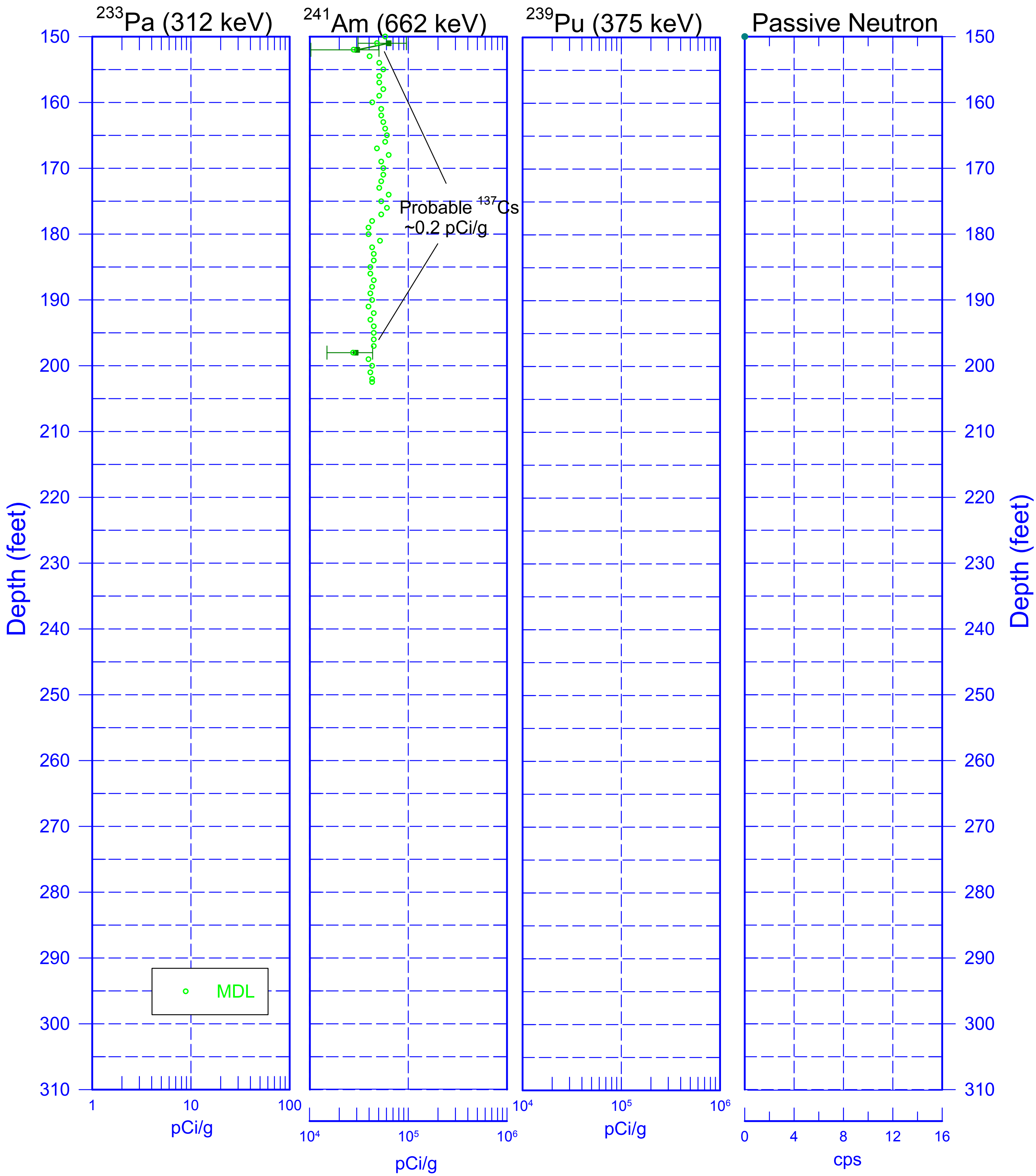


Zero Reference = Top of Casing

Last Log Date - 04/14/05

299-W15-08 (A5468)

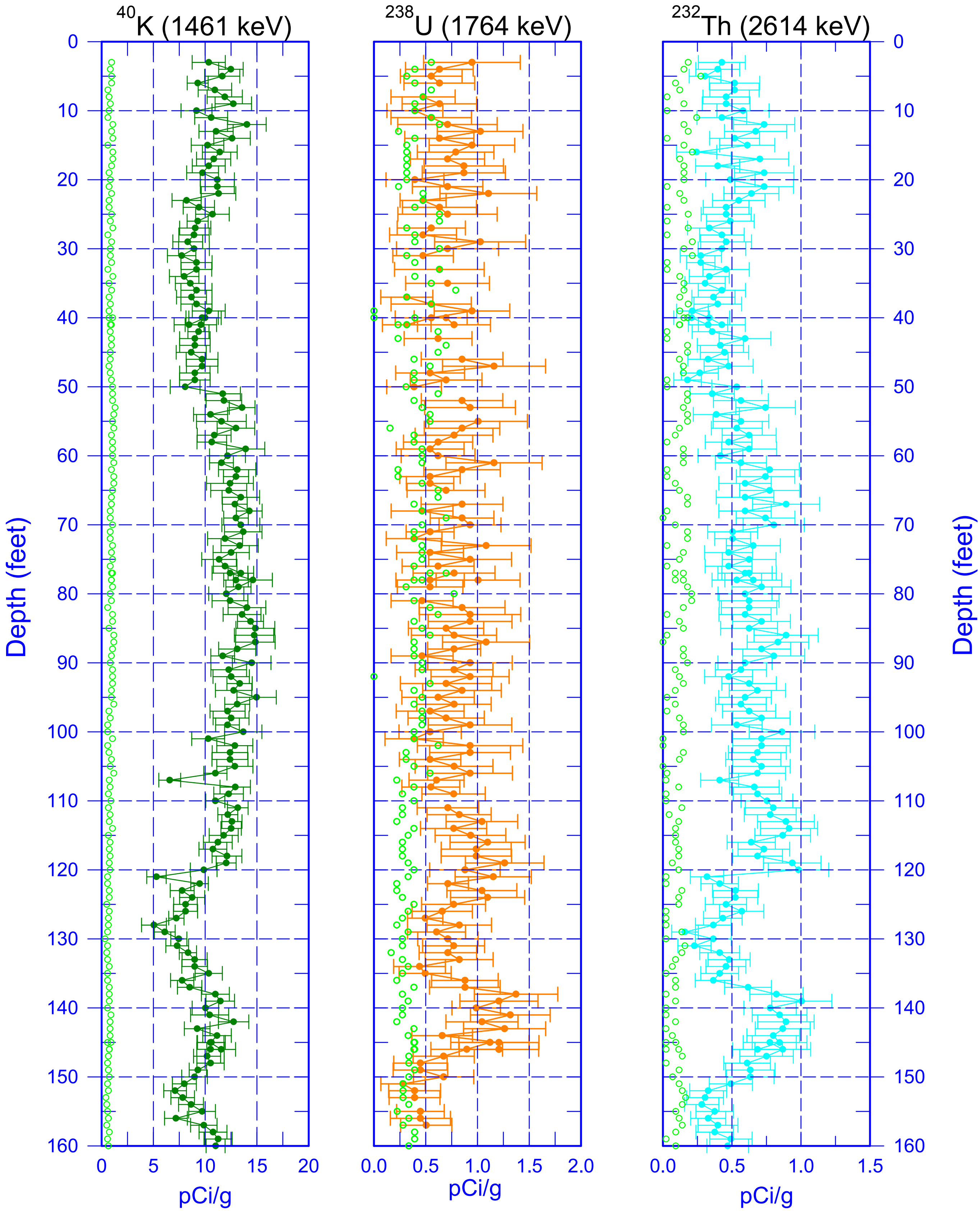
Man-Made Radionuclides



Zero Reference = Top of Casing

Last Log Date - 04/14/05

299-W15-08 (A5468)
Natural Gamma Logs

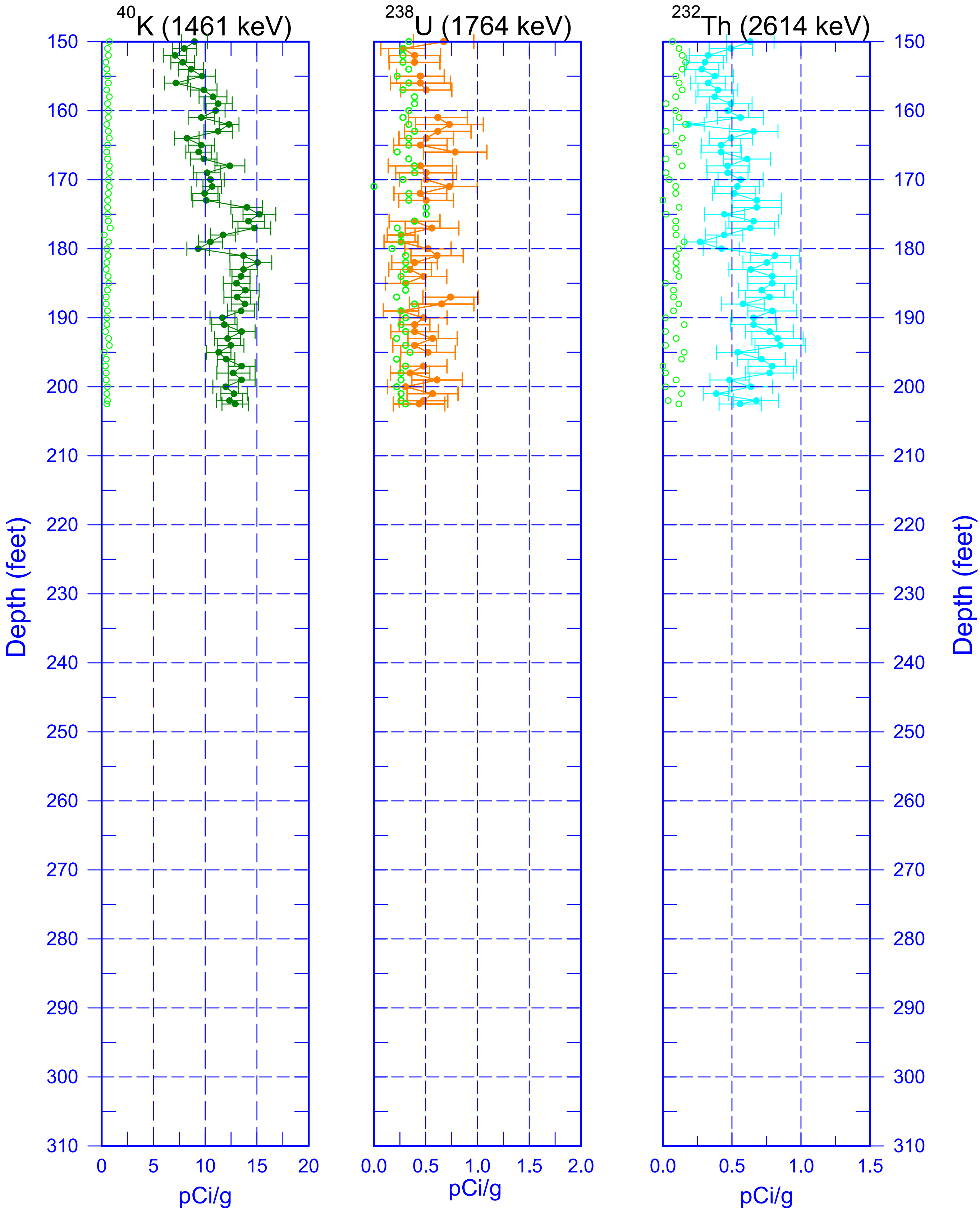


Zero Reference = Top of Casing

Depth scale: 1" = 20 ft

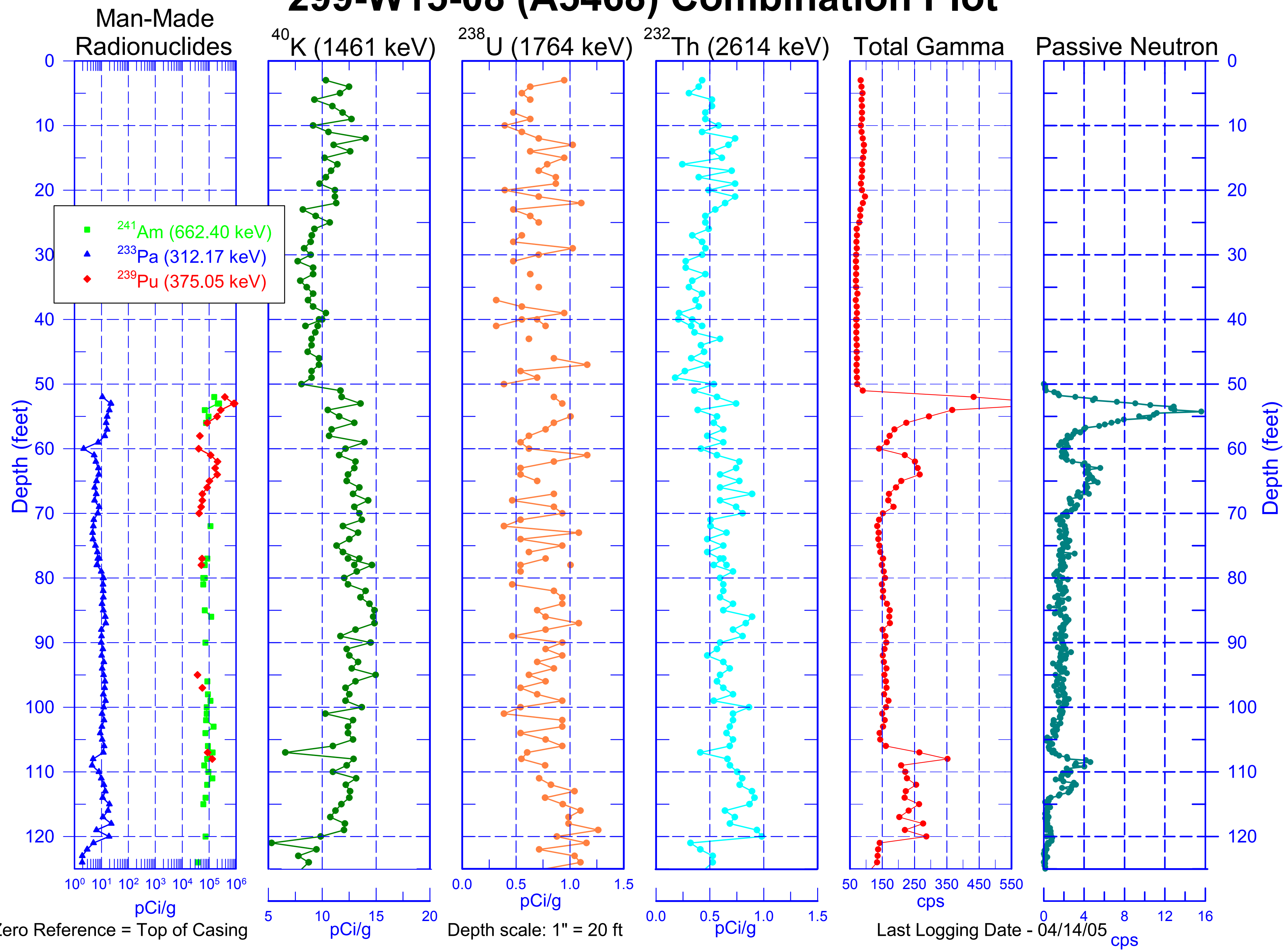
Last Log Date - 04/14/05

299-W15-08 (A5468)
Natural Gamma Logs



Zero Reference = Top of Casing | Depth scale: 1" = 20 ft | Last Log Date - 04/14/05

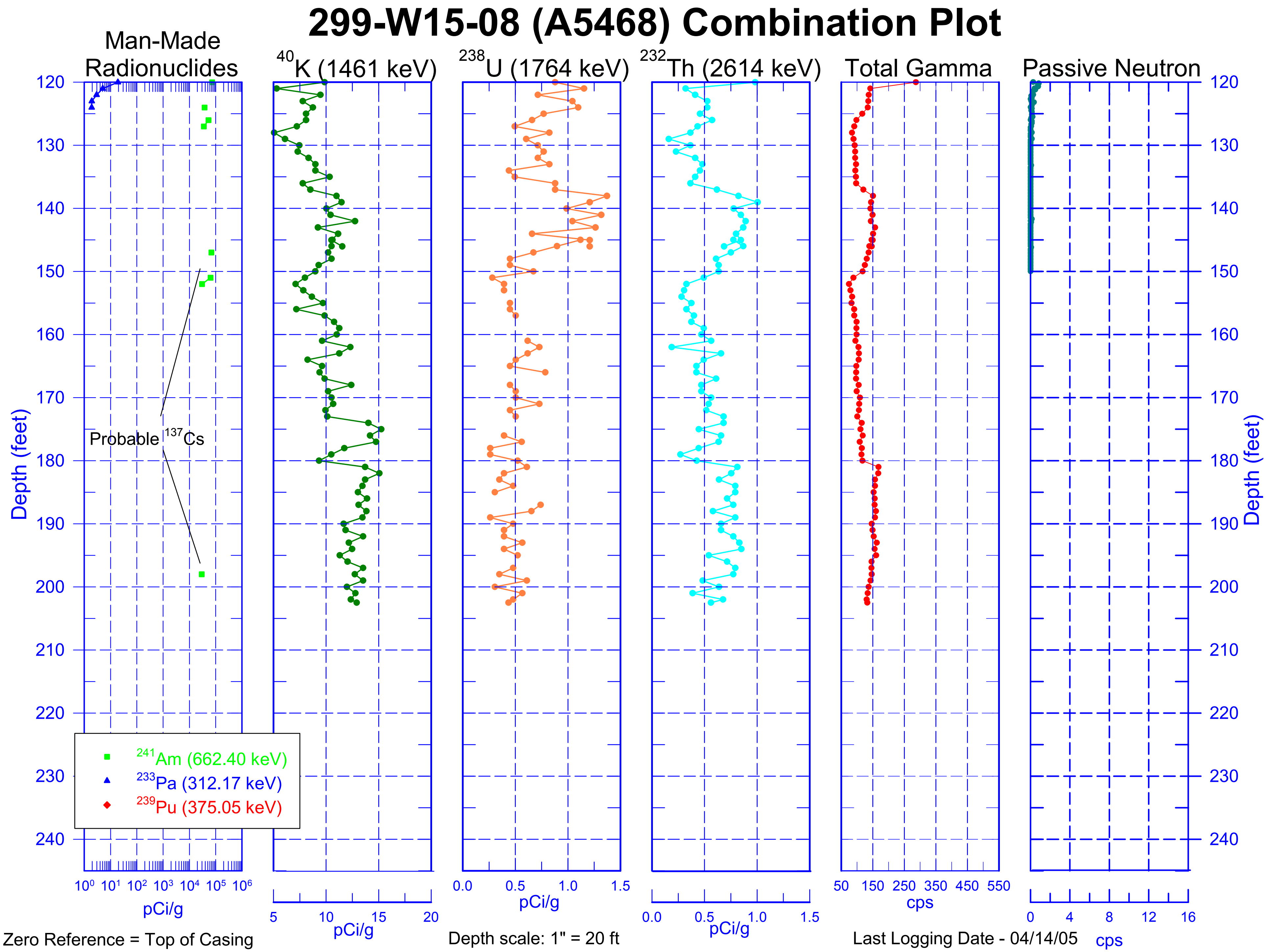
299-W15-08 (A5468) Combination Plot



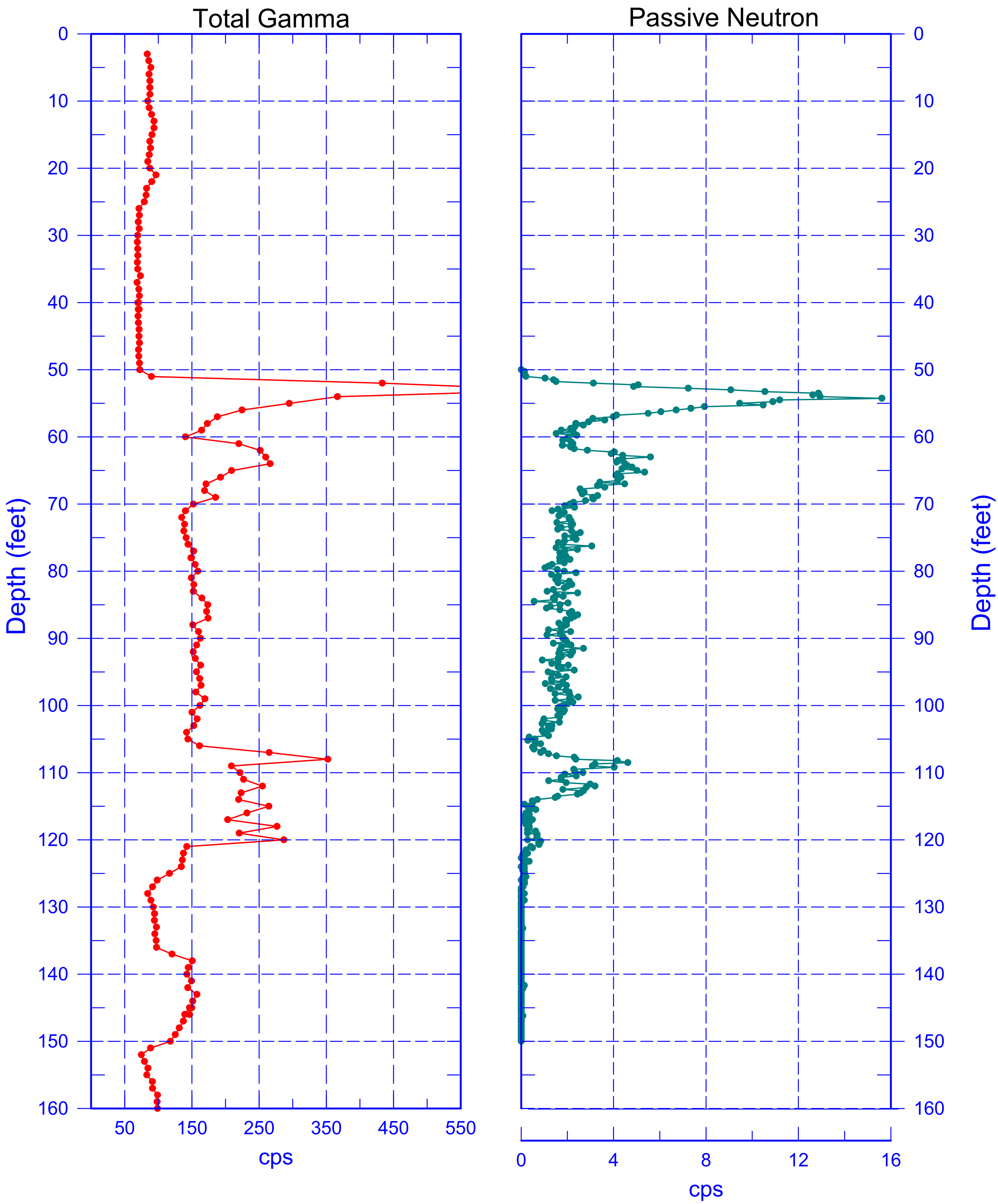
Zero Reference = Top of Casing

Depth scale: 1" = 20 ft

Last Logging Date - 04/14/05


299-W15-08 (A5468) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Passive Neutron
Depth (feet)
Probable 137Cs
241Am (662.40 keV)
233Pa (312.17 keV)
239Pu (375.05 keV)
pCi/g
cps
Zero Reference = Top of Casing
Depth scale: 1" = 20 ft
Last Logging Date - 04/14/05

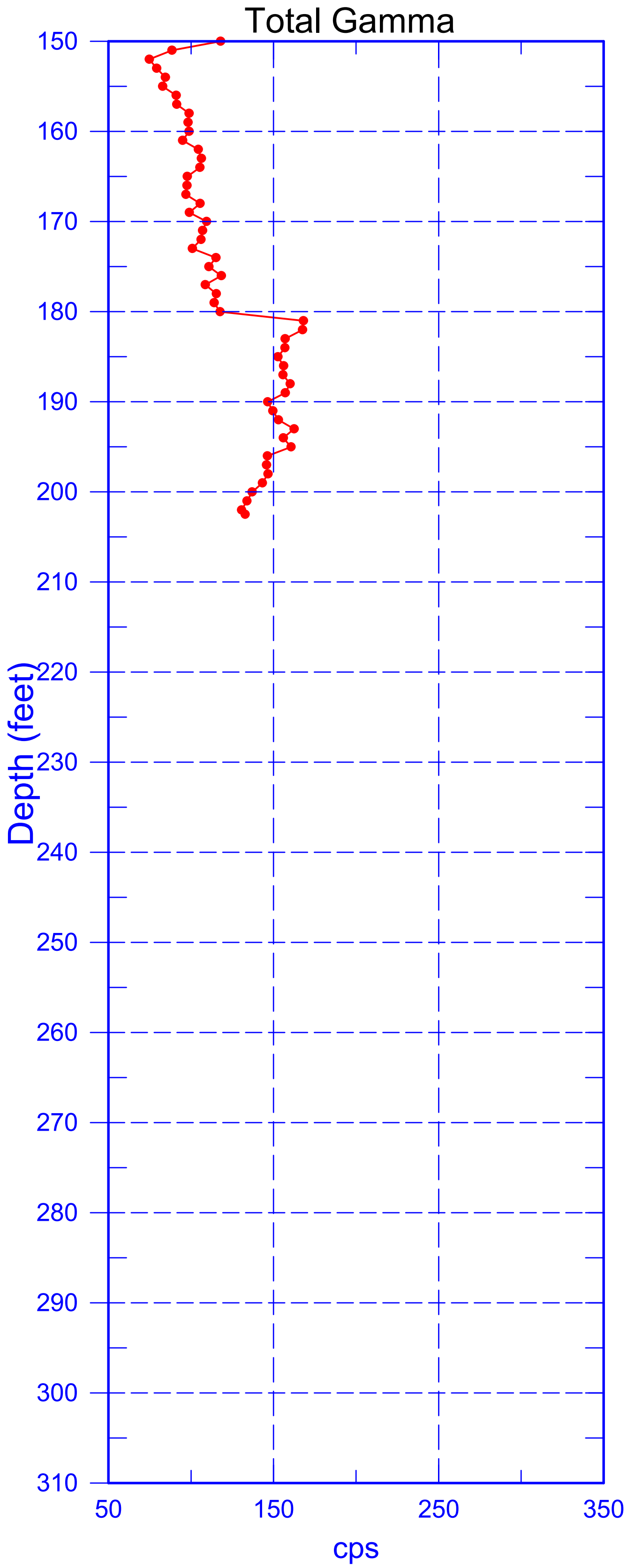
299-W15-08 (A5468)
Total Gamma & Passive Neutron

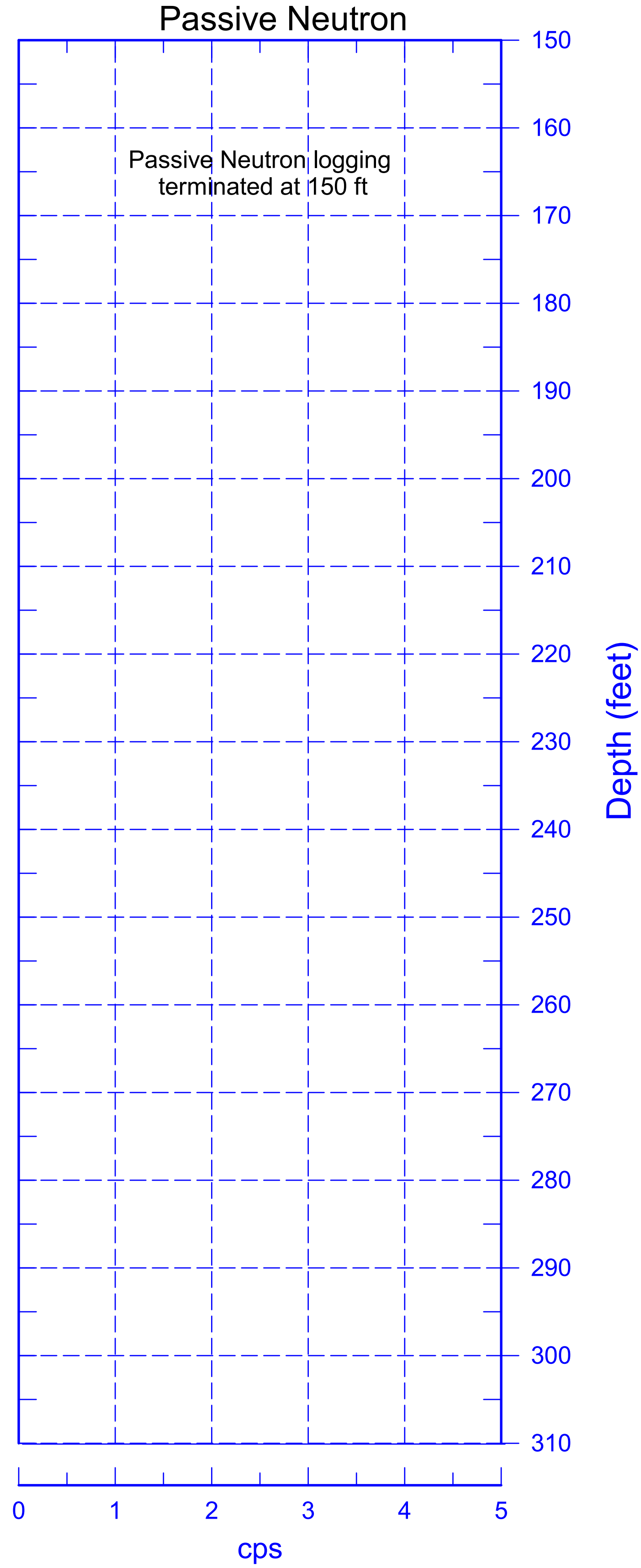


Zero reference = Top of Casing

Last Log Date - 04/14/05

299-W15-08 (A5468)
Total Gamma & Passive Neutron

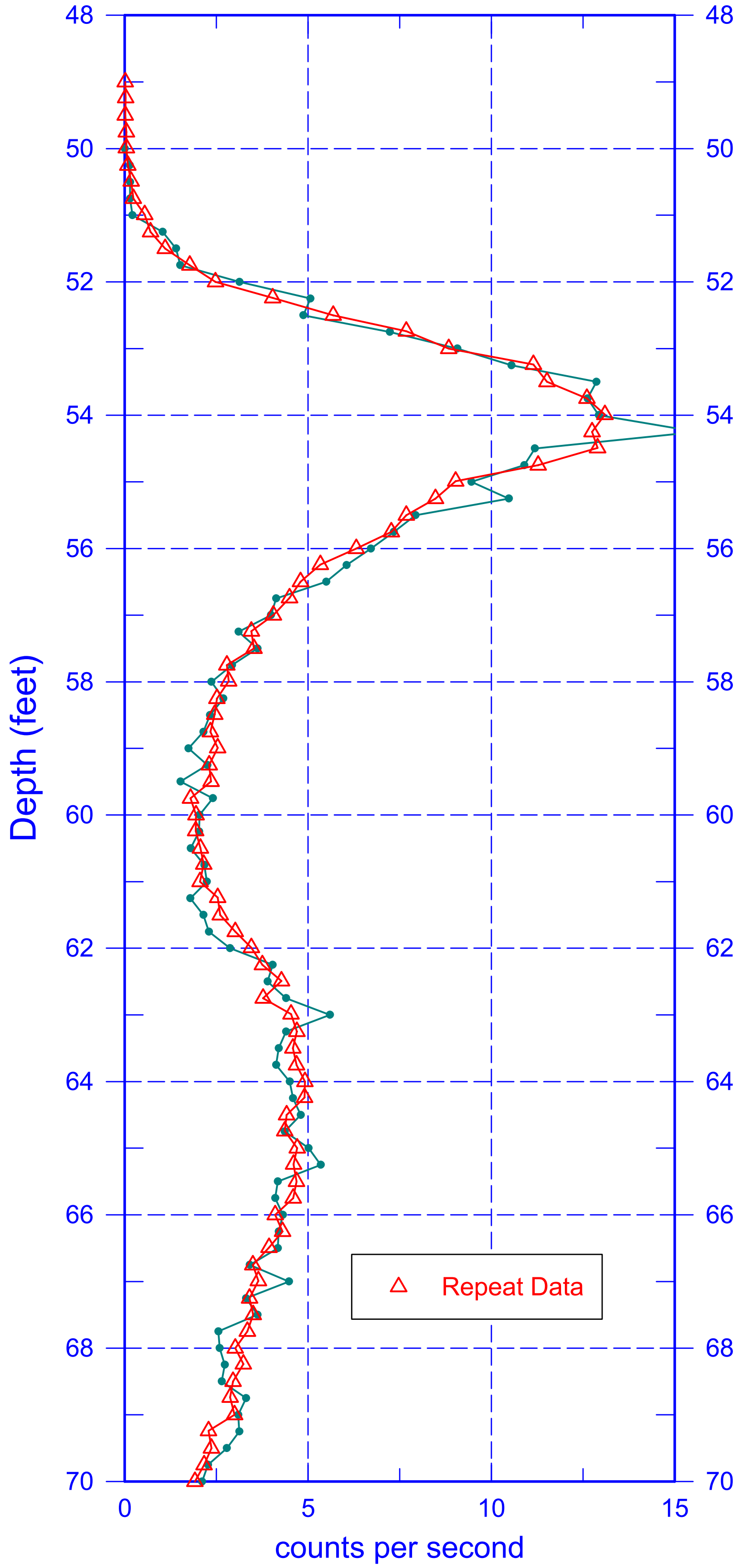




Zero reference = Top of Casing

Last Log Date - 04/14/05

299-W15-08 (A5468)
Passive Neutron Repeat Section

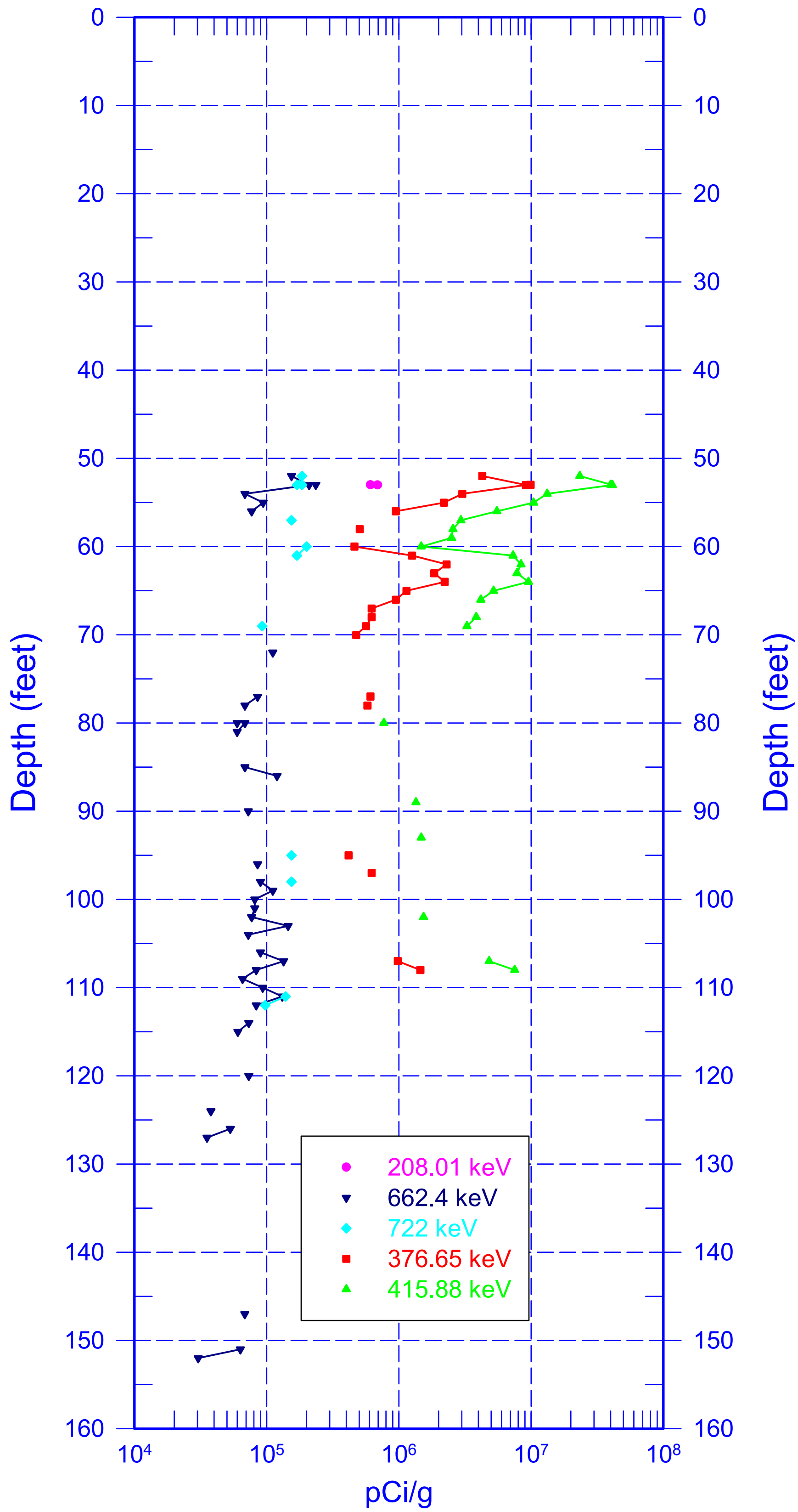


Zero Reference = Top of Casing

Last Log Date - 04/14/05

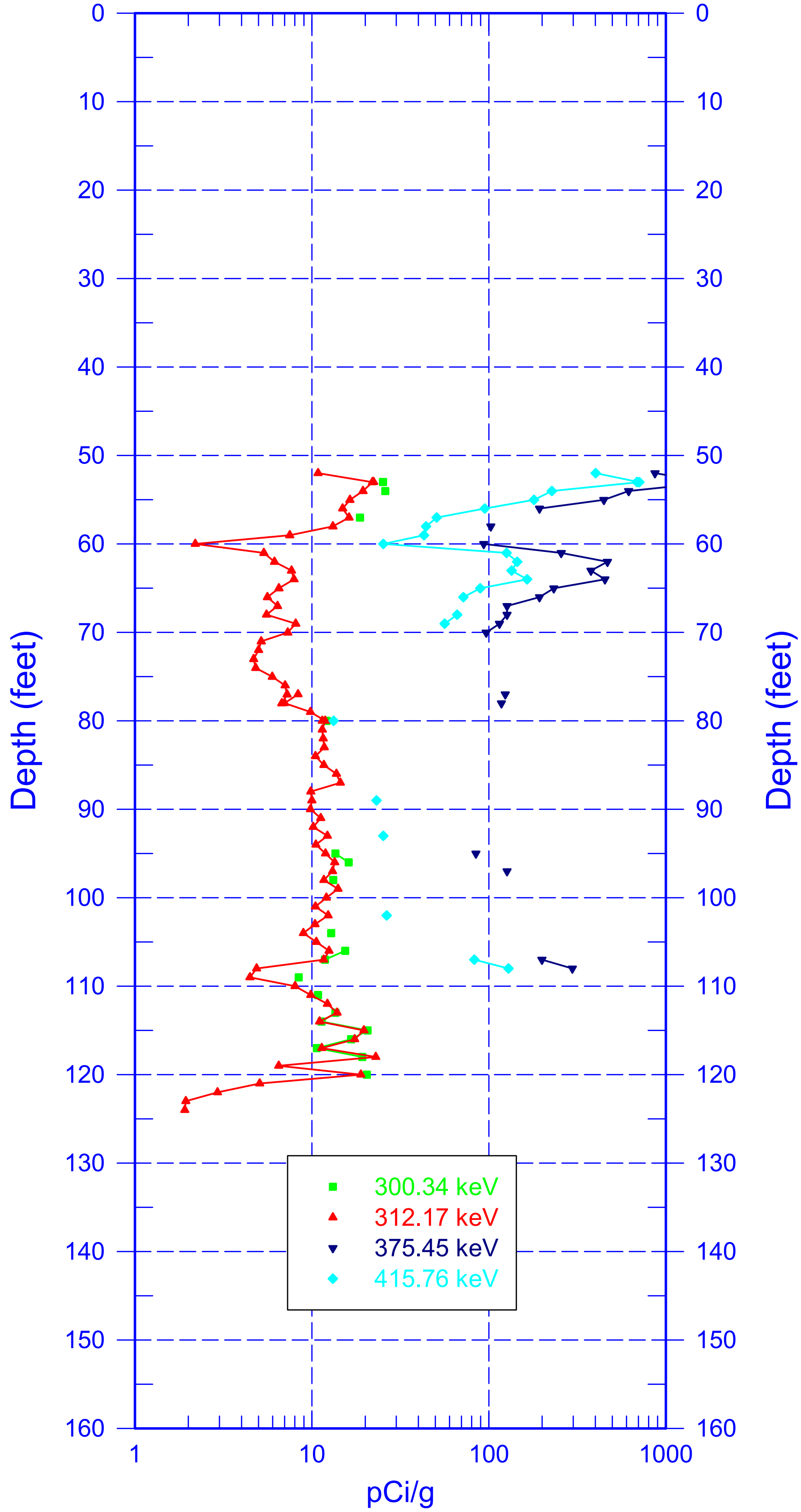
299-W15-08 (A5468)

Am-241 Energy Peak Comparison



Zero Reference = Top of Casing | Depth scale: 1" = 20 ft | Last Log Date - 04/14/05

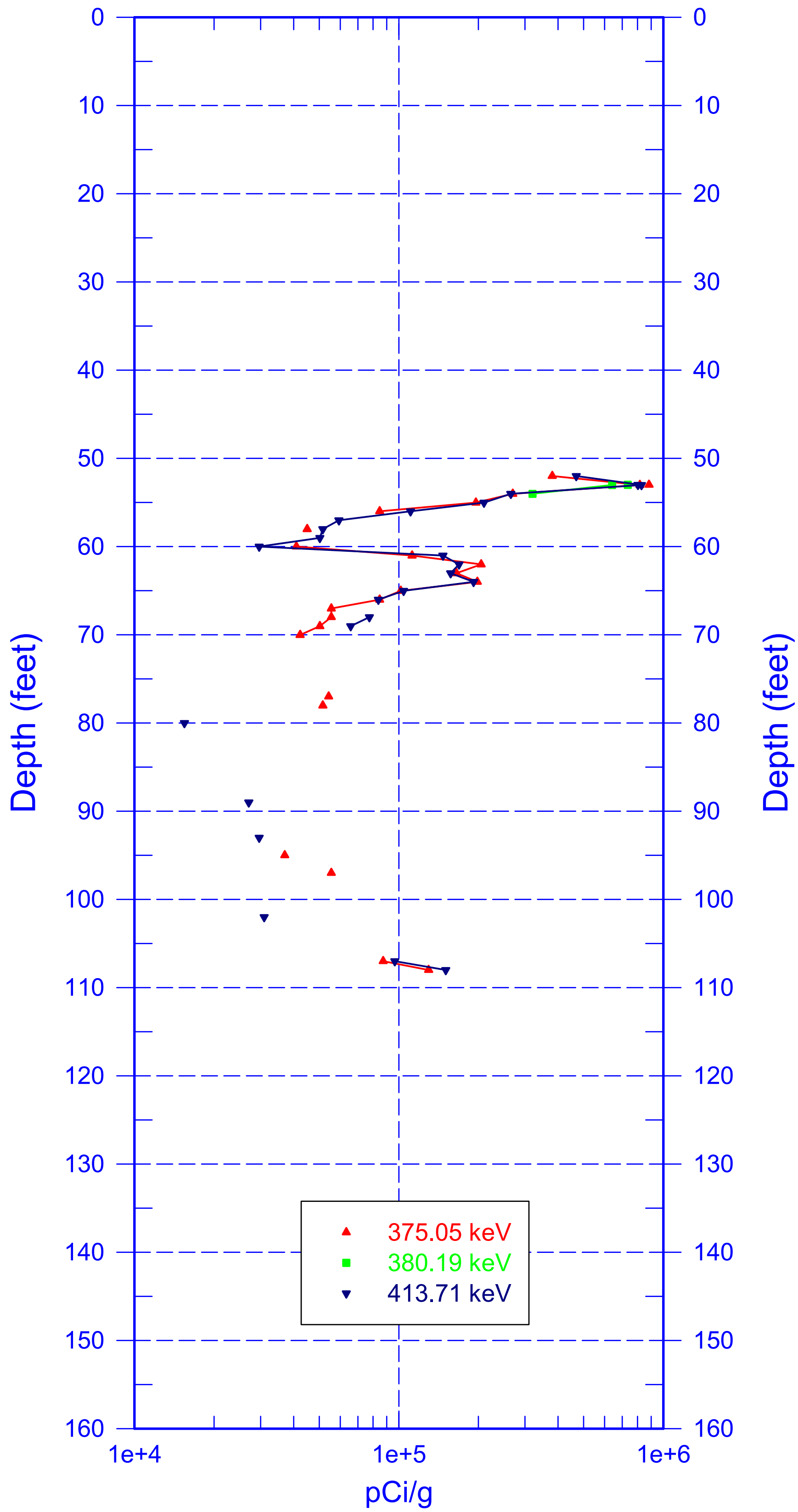
299-W15-08 (A5468)
Pa-233 Energy Peak Comparison



Zero Reference = Top of Casing
Depth scale: 1" = 20 ft
Last Log Date - 04/14/05

299-W15-08 (A5468)

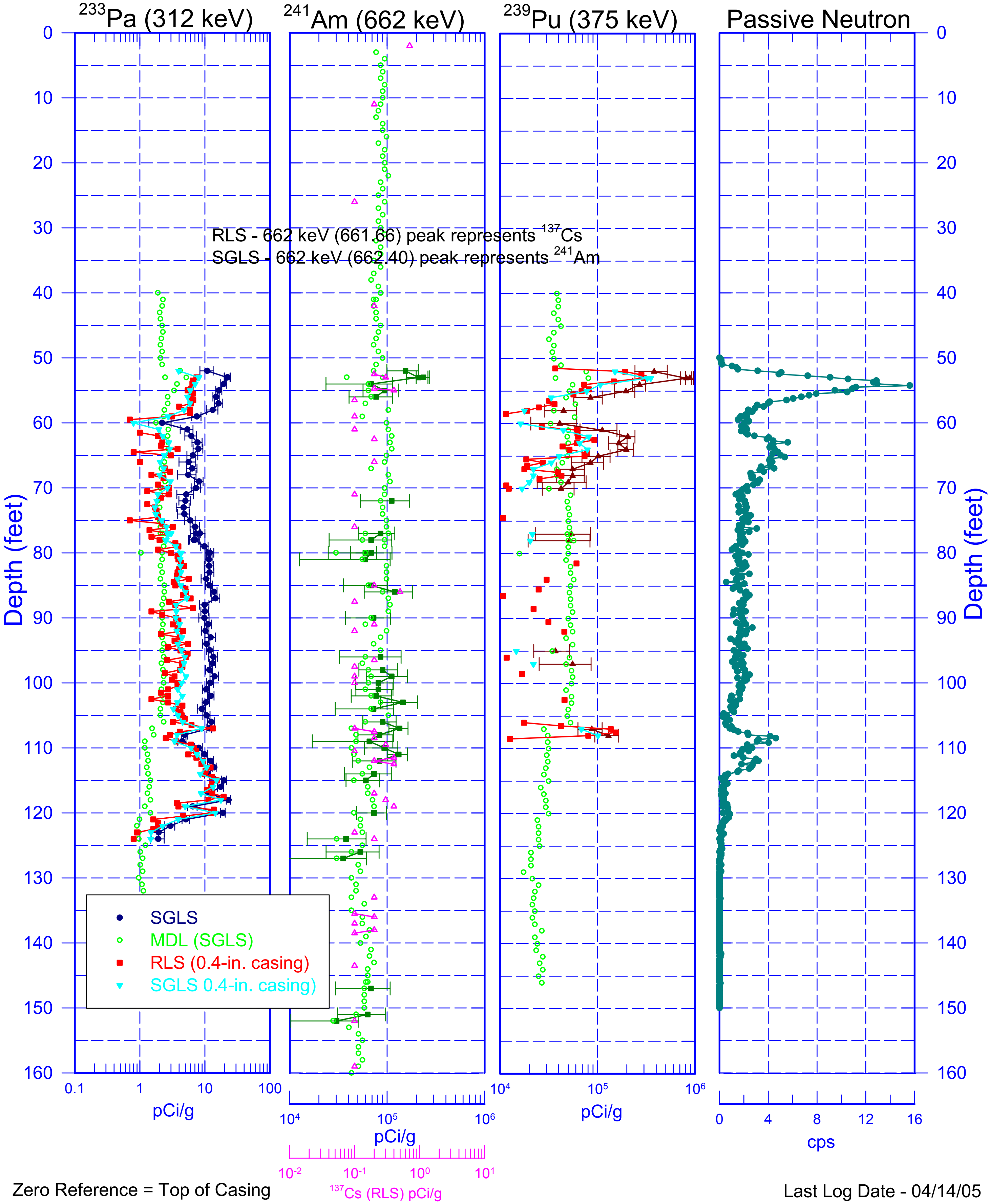
Pu-239 Energy Peak Comparison



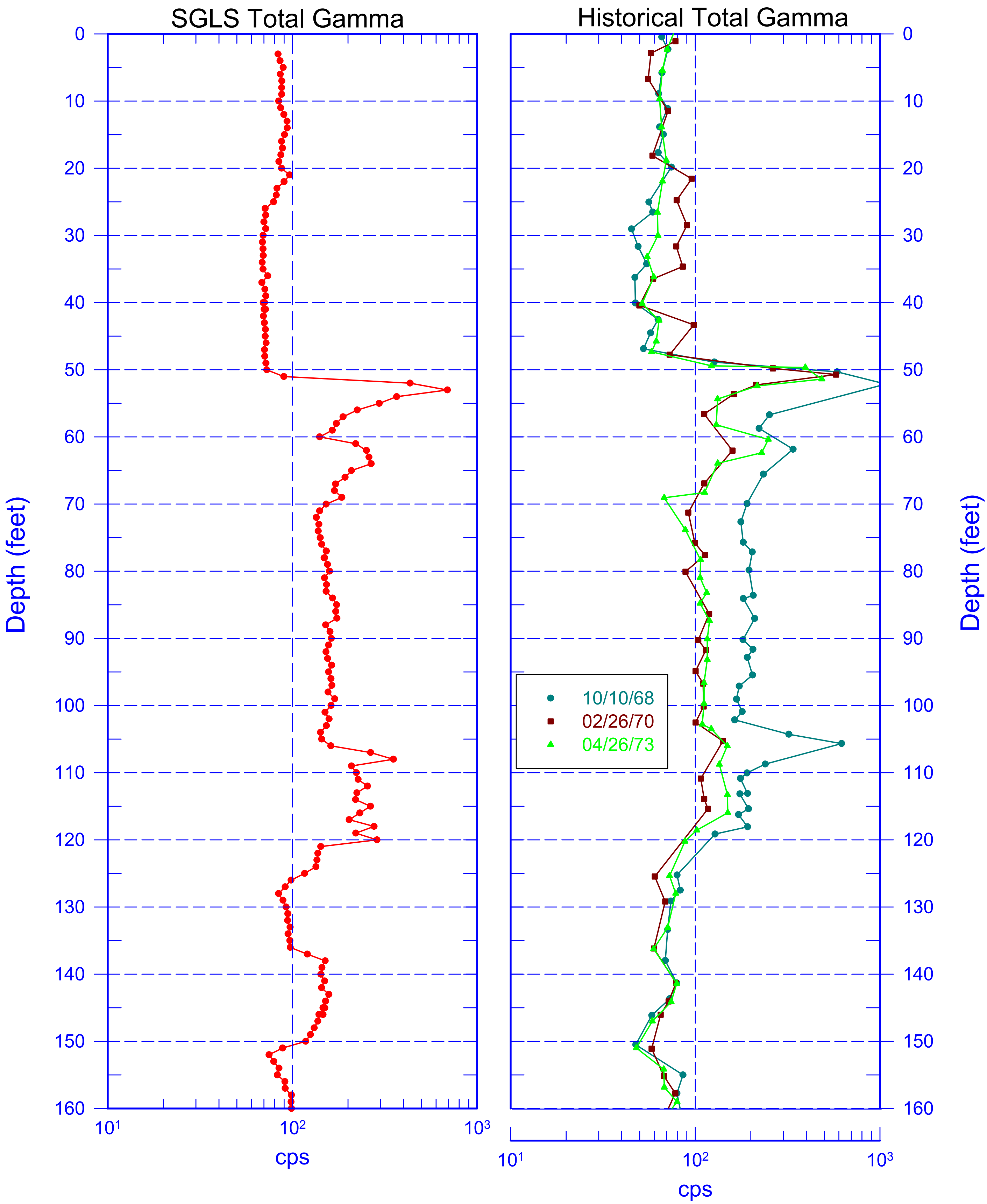
Zero Reference = Top of Casing   Depth scale: 1" = 20 ft   Last Log Date - 04/14/05

299-W15-08 (A5468)

Comparison of SGLS & RLS Man-Made Radionuclides



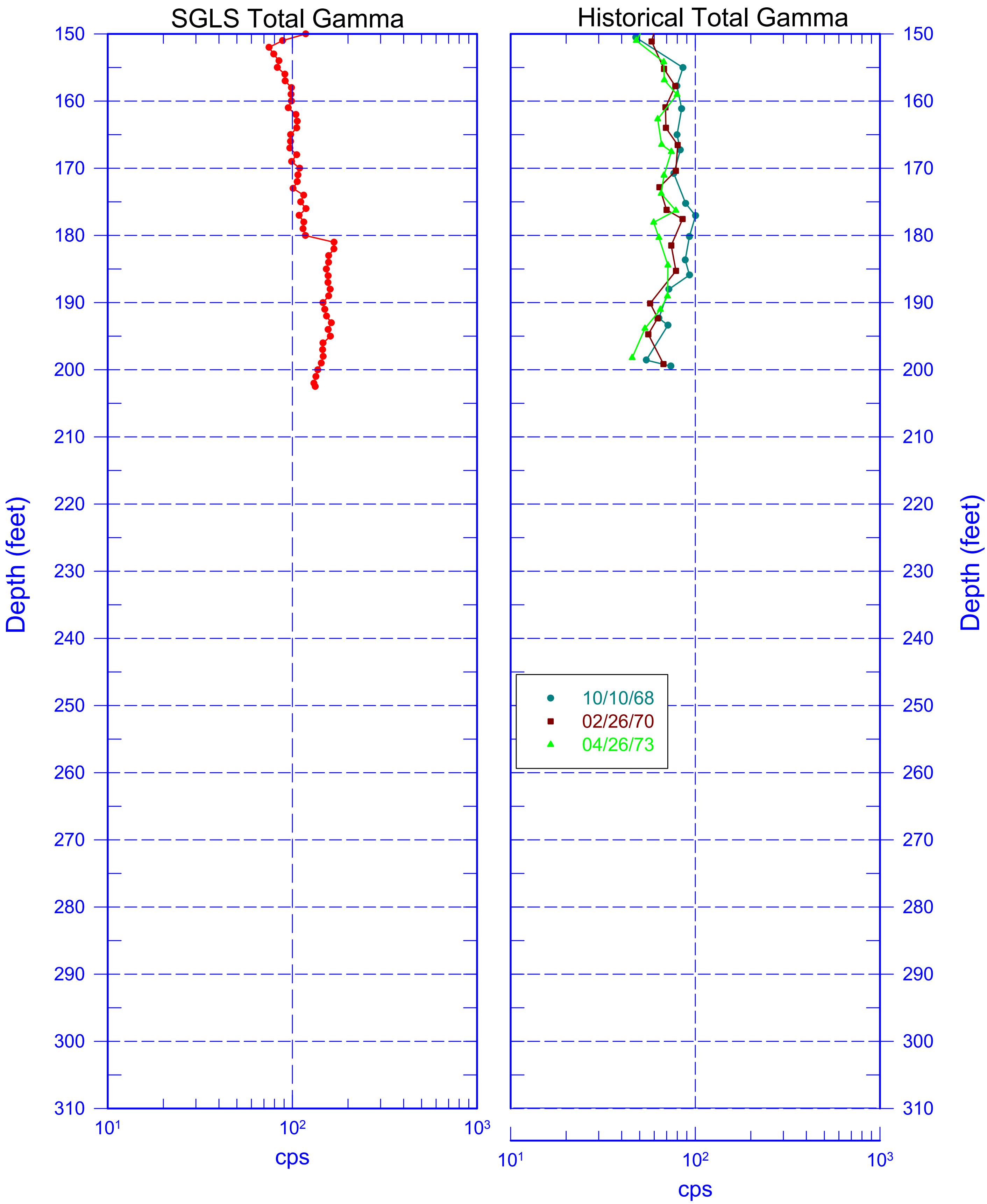
299-W15-08 (A5468)
SGLS & Historical Total Gamma



Zero reference = Top of Casing

Last Log Date - 04/14/05

299-W15-08 (A5468)
SGLS & Historical Total Gamma



Zero reference = Top of Casing

Last Log Date - 04/14/05